“Laboratory measurement of the brighter-fatter effect in an H2RG infrared detector”
arXiv: 1712.06642

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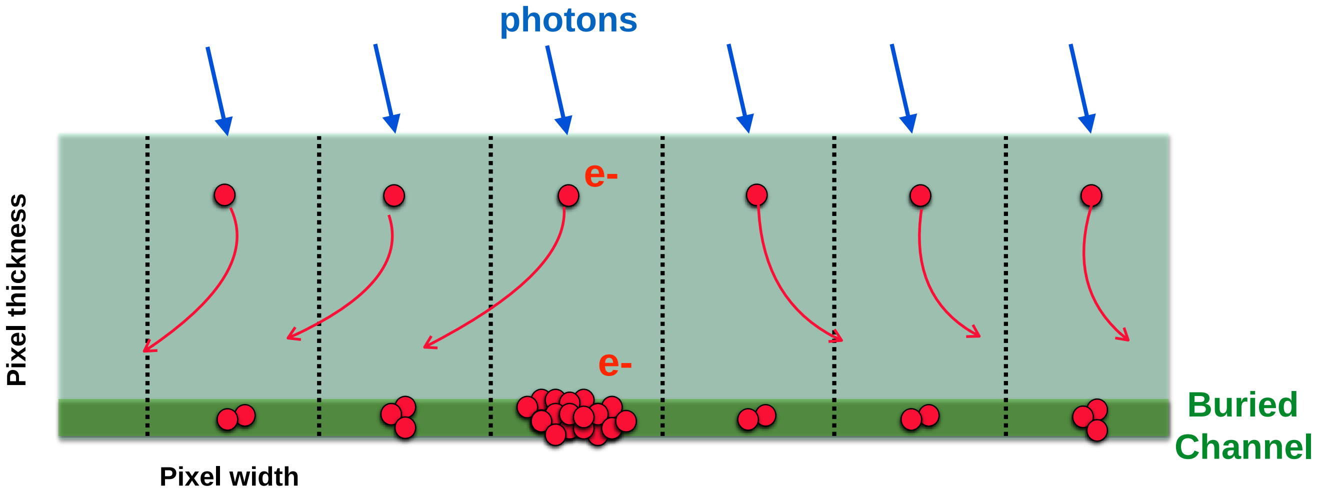
The BF effect in CCDs

Inhomogenous distribution of the charges resulting from :

- Contrast from the photon noise in flatfield images.
- PSF of a star.

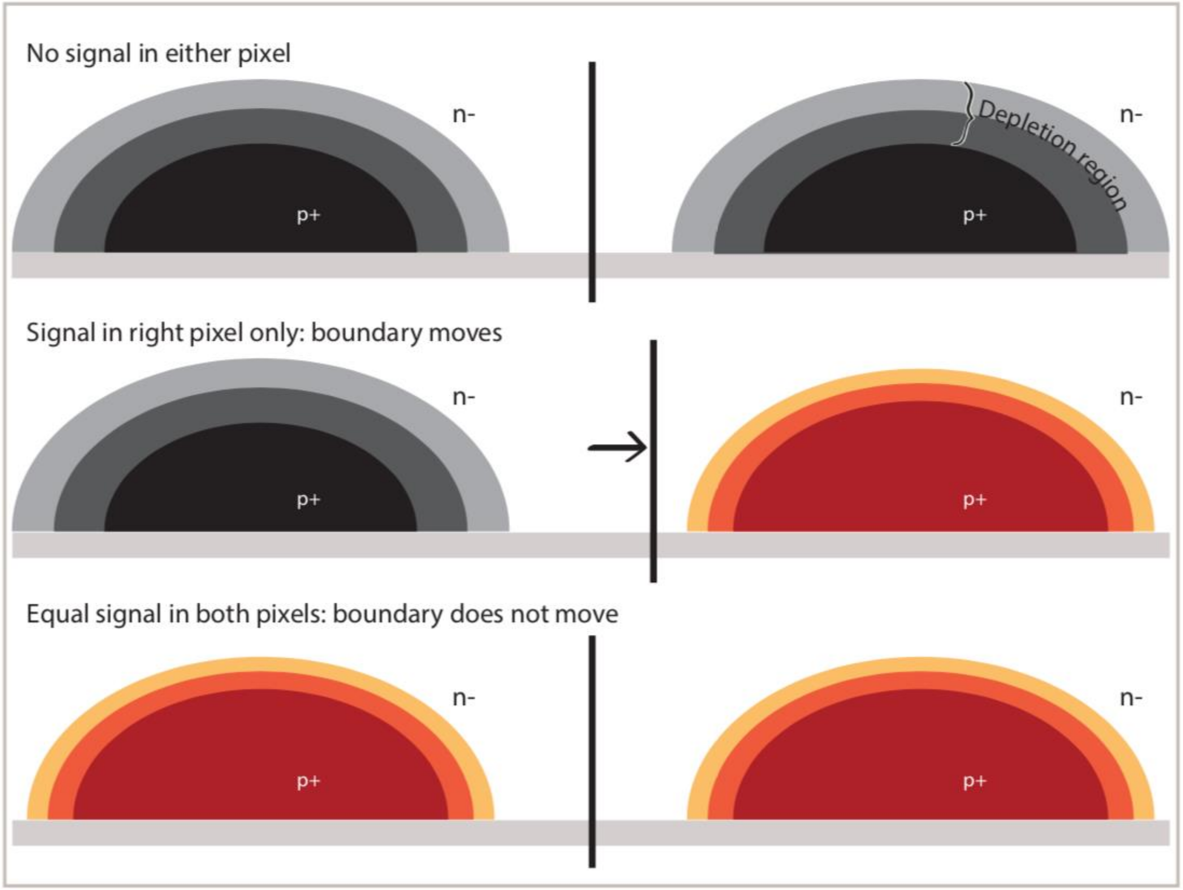
CCD model Image Credit: Augustin Guyonnet



- BF has been seen in Decam, Megacam, LSST CCDs, HSC CCDs.

- Bad for weak lensing: misrepresentation of PSF model. DES: discard brightest stars to minimize impact on shear measurements (Jarvis et 2015, Zuntz et al. 2017).

The BF effect in HXRG detectors?

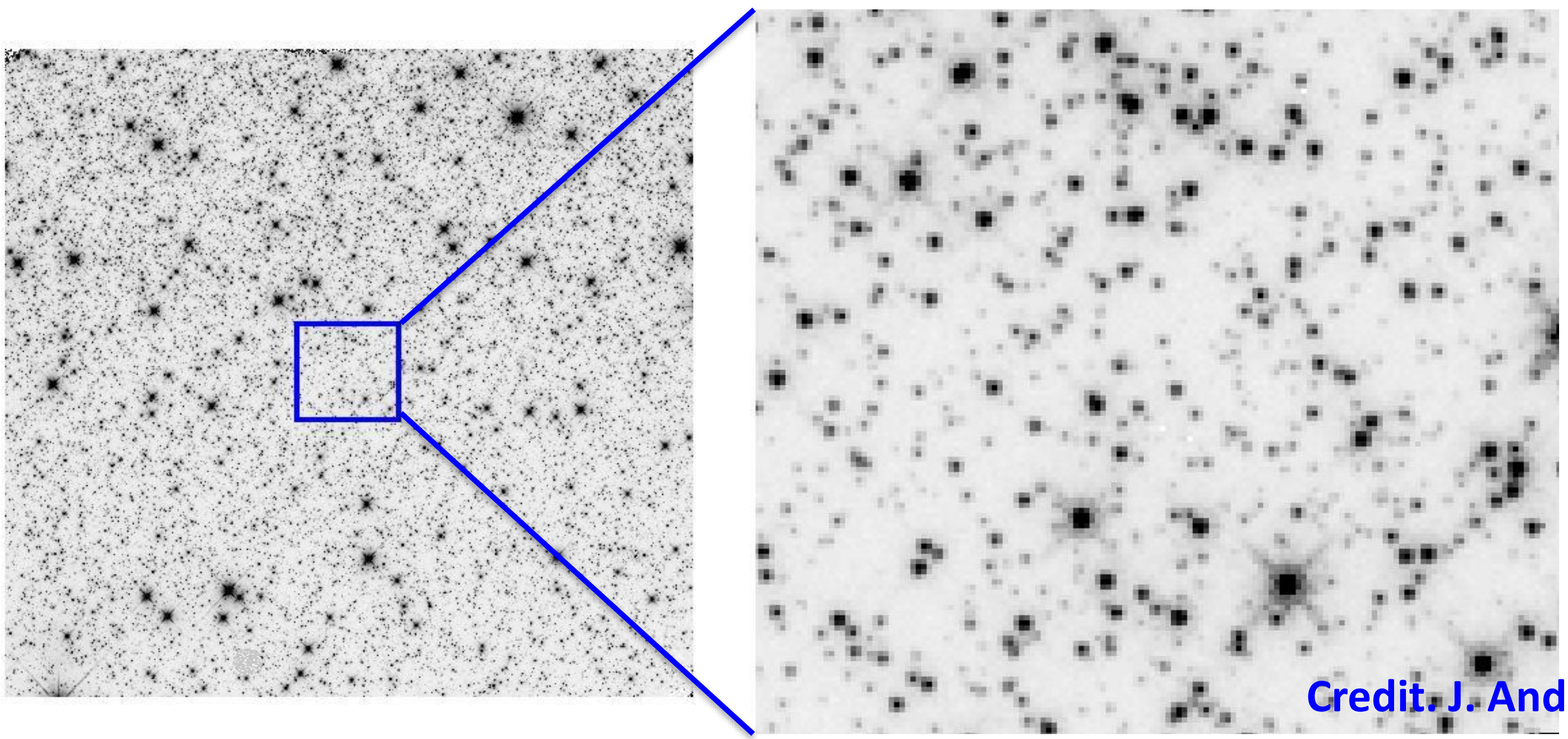


As in CCDs, the effective pixel boundaries shift.

Image from **Plazas et al 2017:** “Nonlinearity and pixel shifting effects in HXRG infrared detectors ”
Concept: Roger Smith (Caltech Optical Observatories)

WFC3-IR (H1RG) data

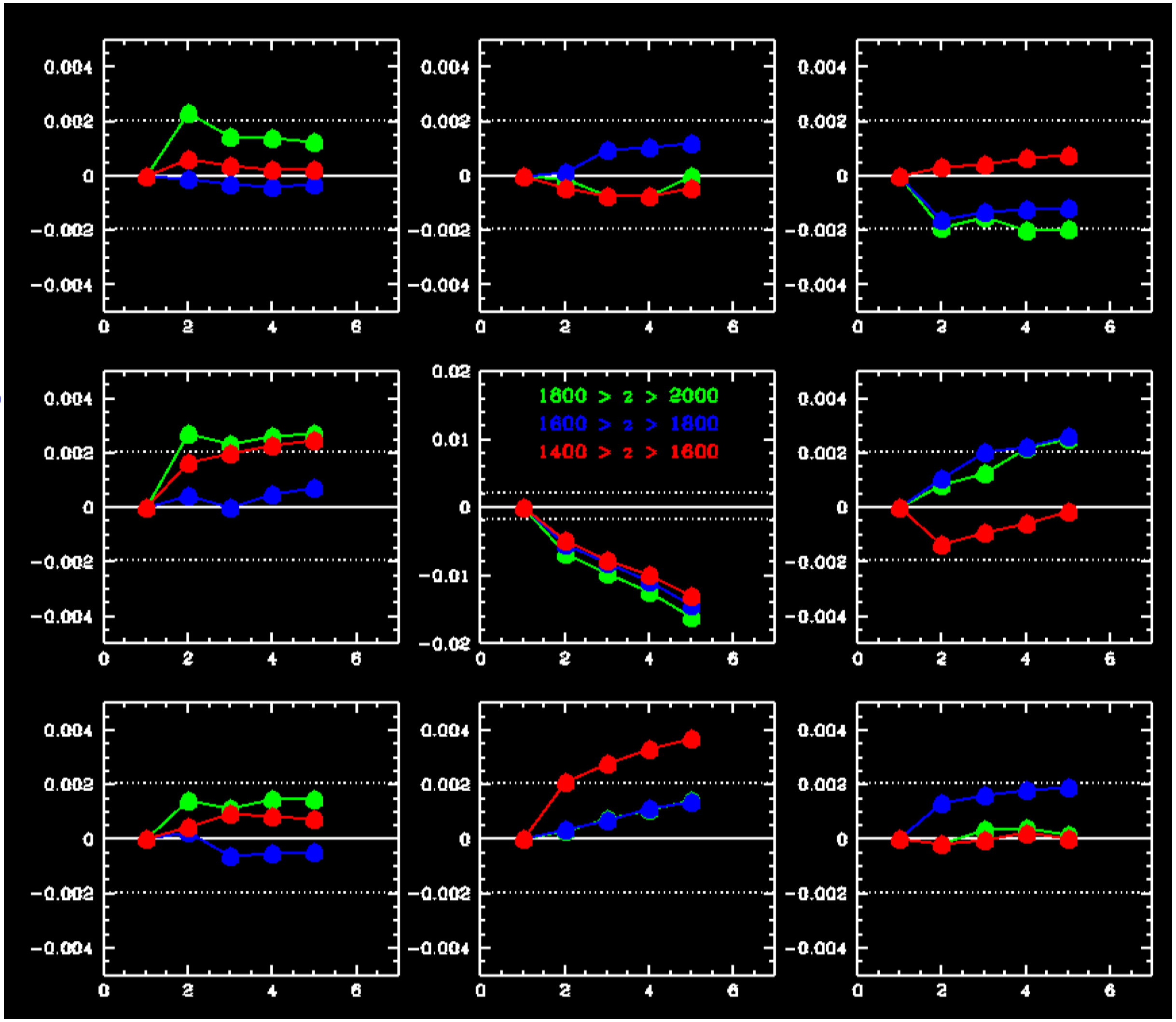
- WFC3-IR data: : Omega-cen globular cluster.
- Polynomial NL correction applied: third order (Hilbert 2014).
- Bright isolated and unsaturated stars, with centers within +/- 0.1 pixel of the pixel center.
- Examine inner 3x3 pixels in terms of how the flux in later reads compares to the flux in read #1.



Credit. J. Anderson

WFC3-IR (H1RG) data

Normalized pixel flux



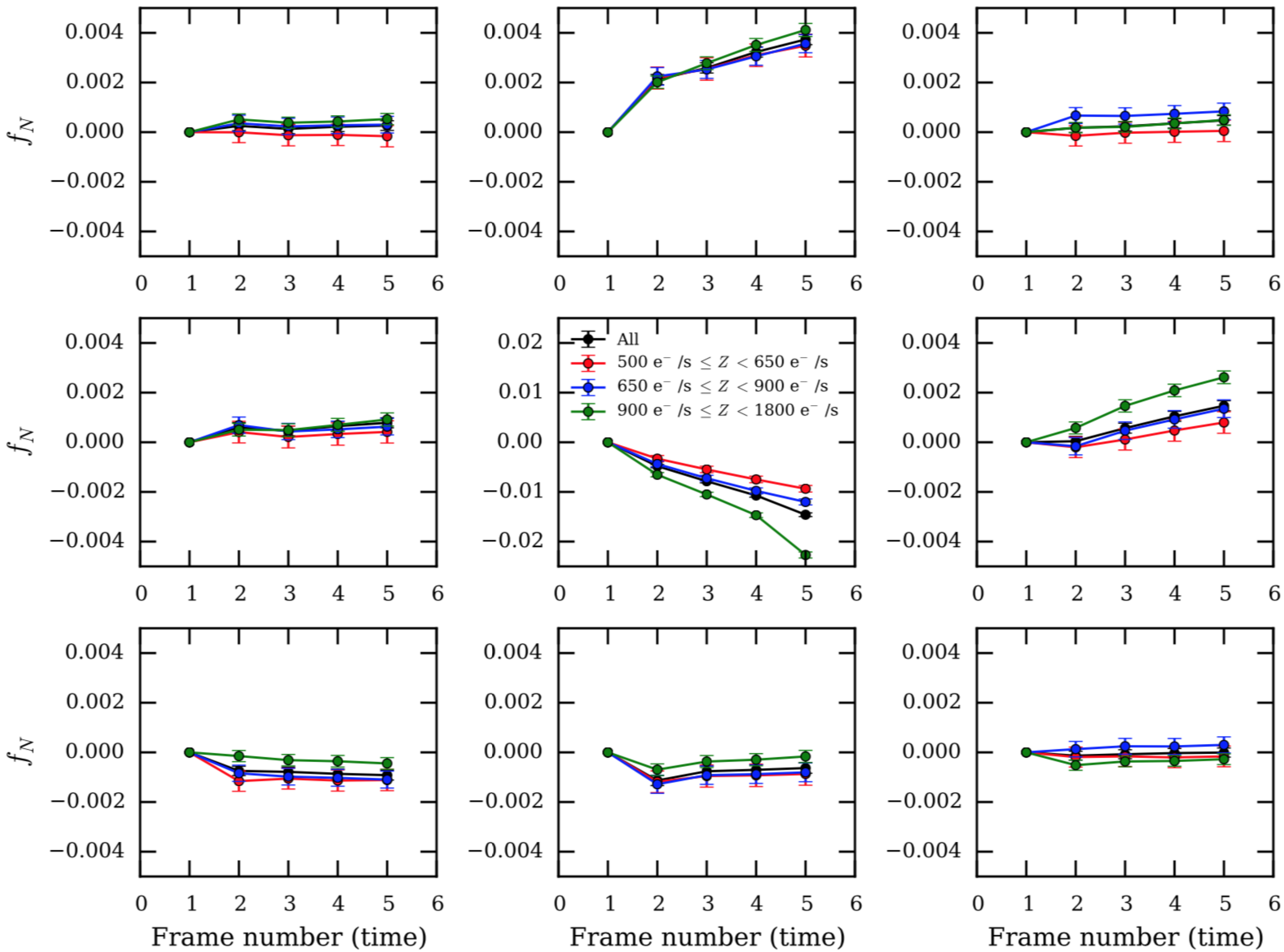
Sample number

-General decrease in the value of the central pixel with time w.r.t read #1

- Adjacent pixels seem to show an increase of flux

Image and analysis: J. Anderson

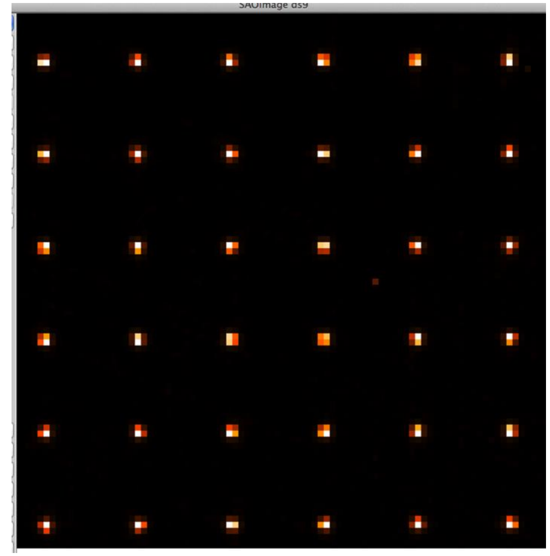
WFC3-IR (H1RG) data

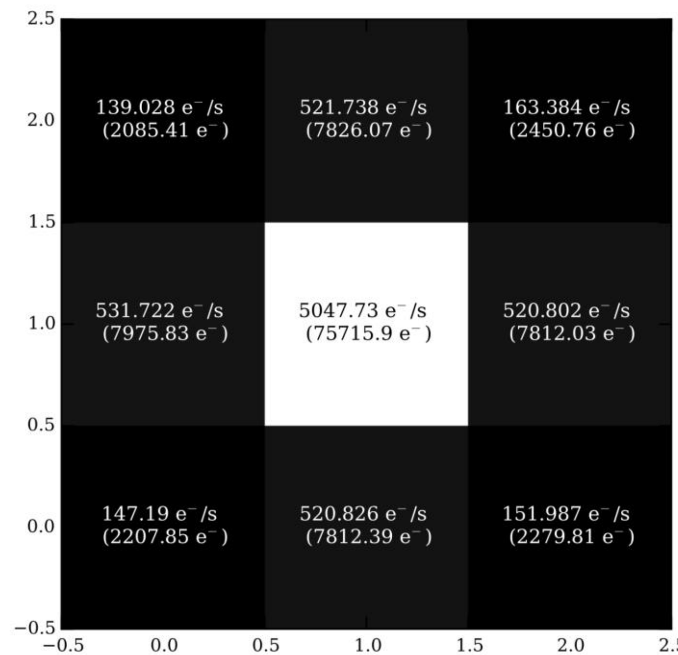


Plazas et al 2017: “Nonlinearity and pixel shifting effects in HXRG infrared detectors ”

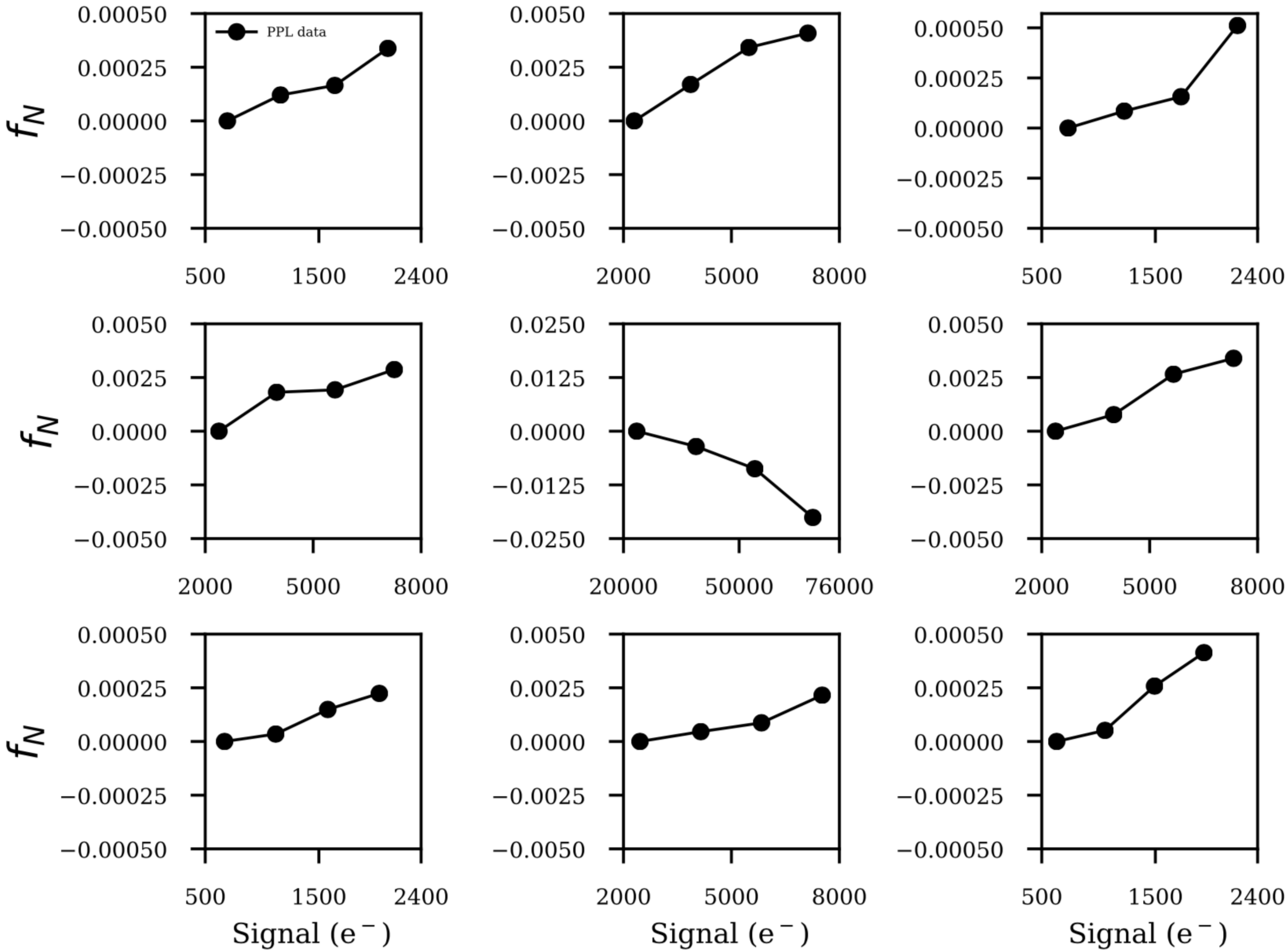
PPL measurements: grid of spots

- Teledyne Hawaii-2RG (#18546), Euclid engineering grade ; HgCdTe detector; 18µm pixels, 2k x 2k format; Cutoff wavelength 2.4 µm.
- At PPL, H2RG was cooled to 95K, operated by Leach controller at 166 kHz.
- A spot grid image (~17,000 spots) covers most of the detector. Spacing = 274.5µm = 15.25 pixels.
- **Using f/11 aperture and 1µm illumination**, the minimum spot width with charge diffusion and jitter is ~ 14µm = 0.78 pixels (full-width half-max)
- Create stack of flat fields and spots, from about 85 ramps (for darks, 10 ramps).
- Calibrations applied to images: dark subtraction, conversion gain, pixel-wise nonlinearity, “bad” (outlier) pixels set to 0



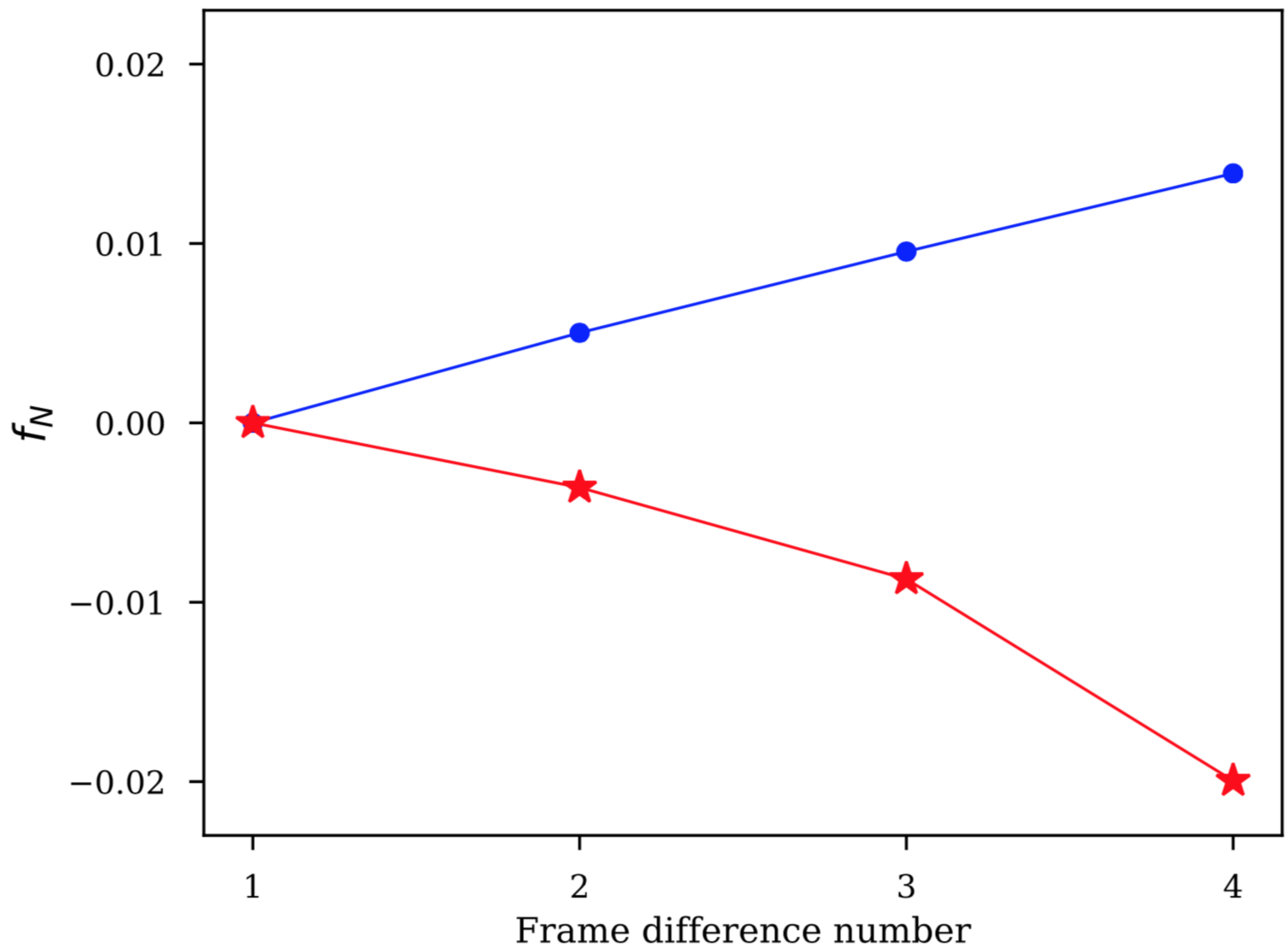


PPL data: spots at center of pixel



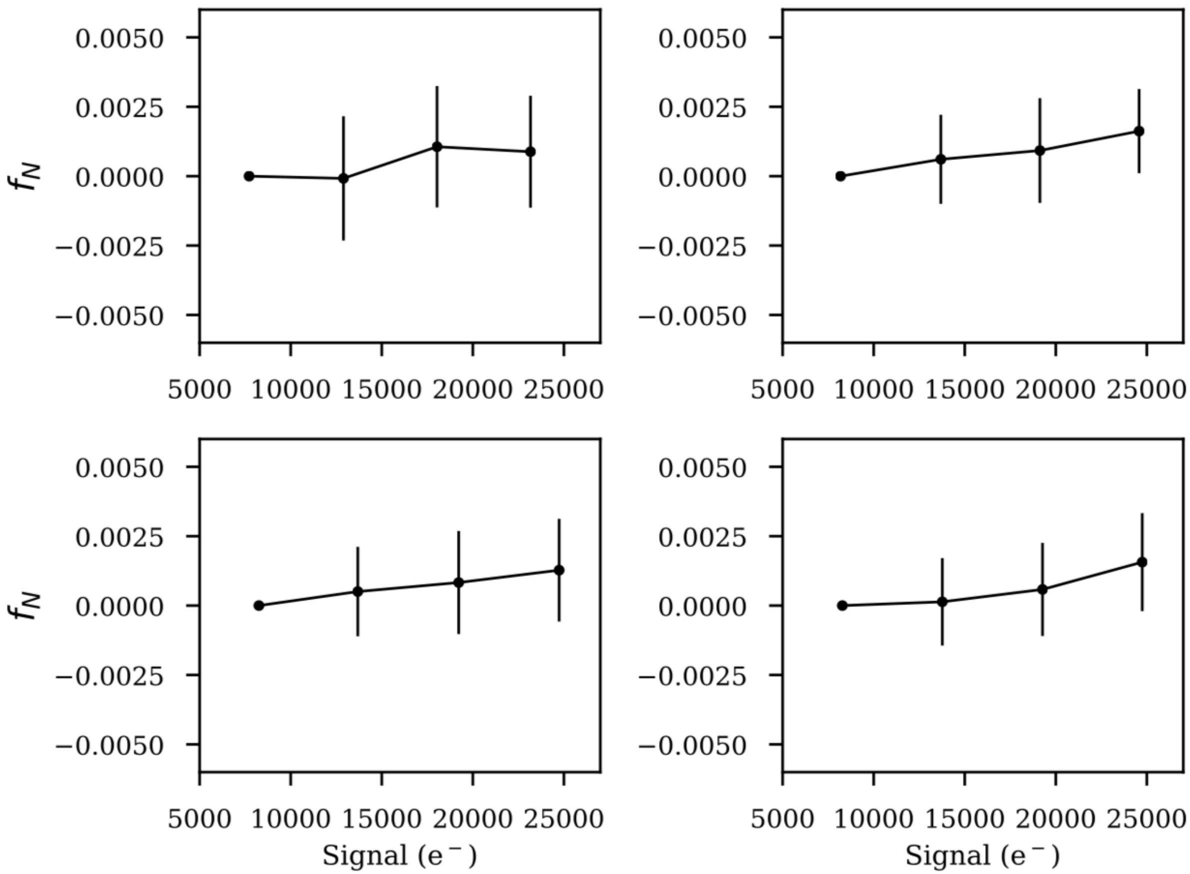
$$f_{\mathrm{N}}(k) = \frac{F_k - F_1}{F_*}$$

Charge conservation

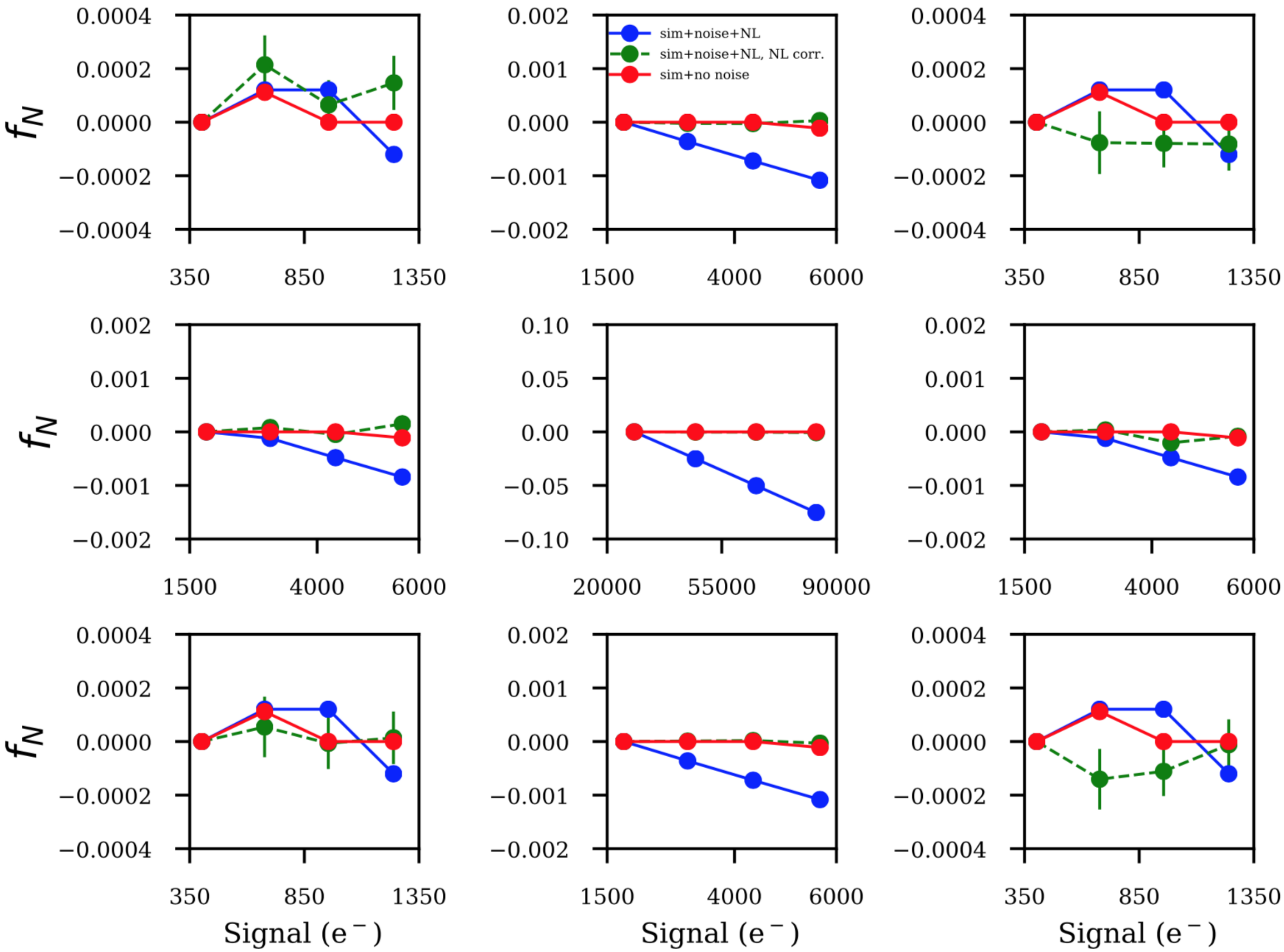


PPL data: spots at corner of pixel

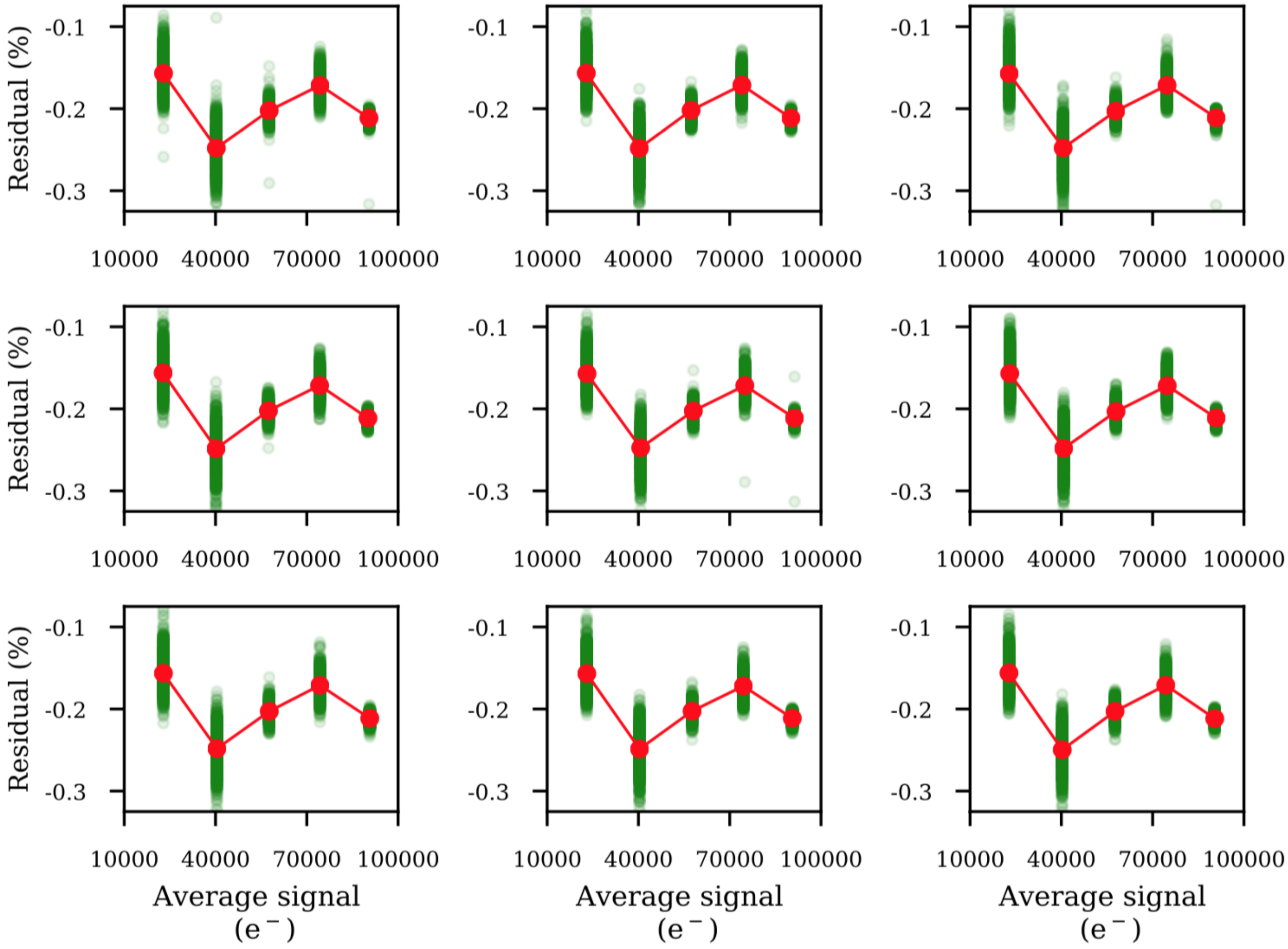
- Most of the light falls in four pixels. Contrast is minimized, attenuation of effect expected.



Pipeline check with simulations

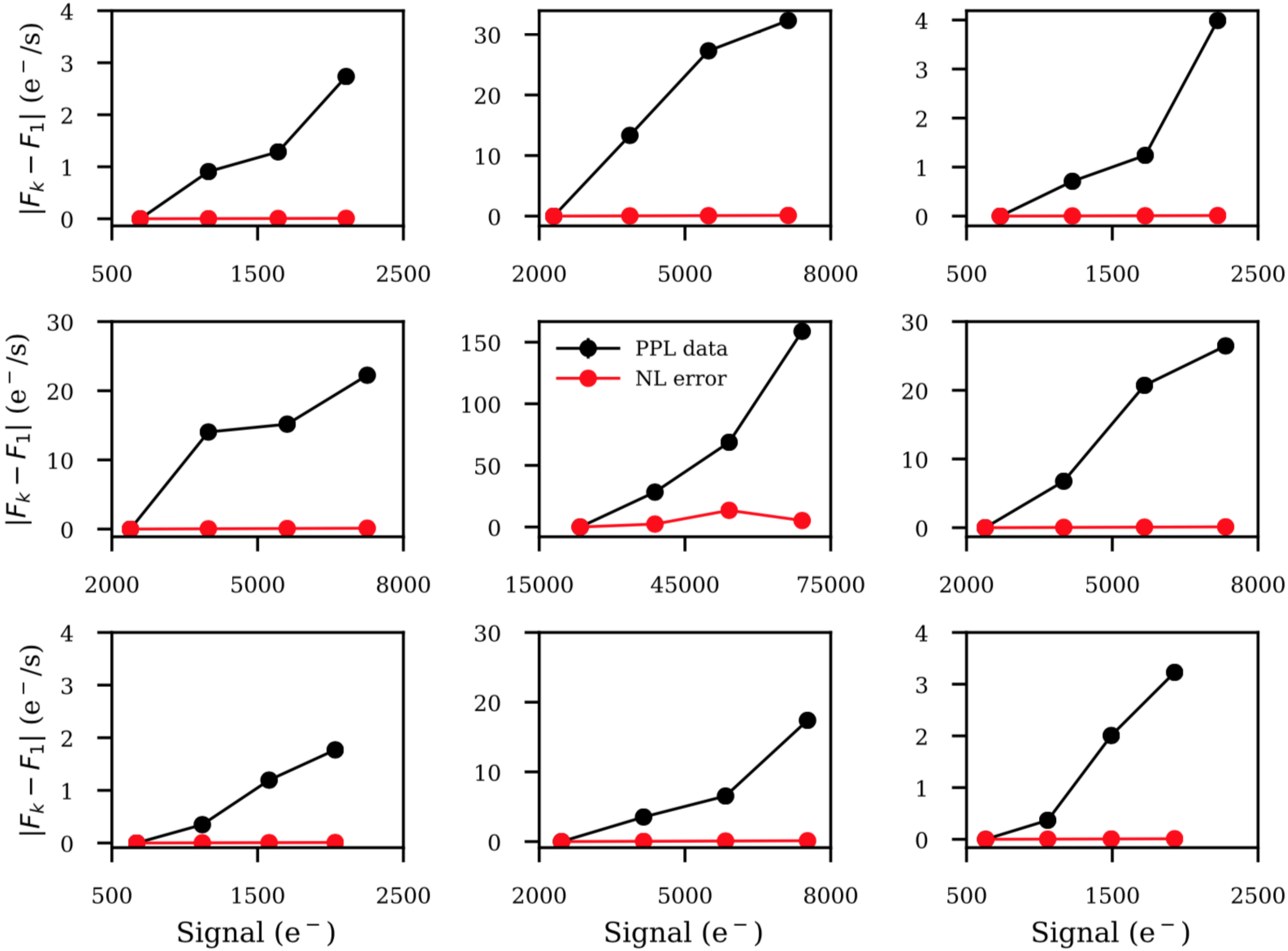


Non-linearity calibration using flats

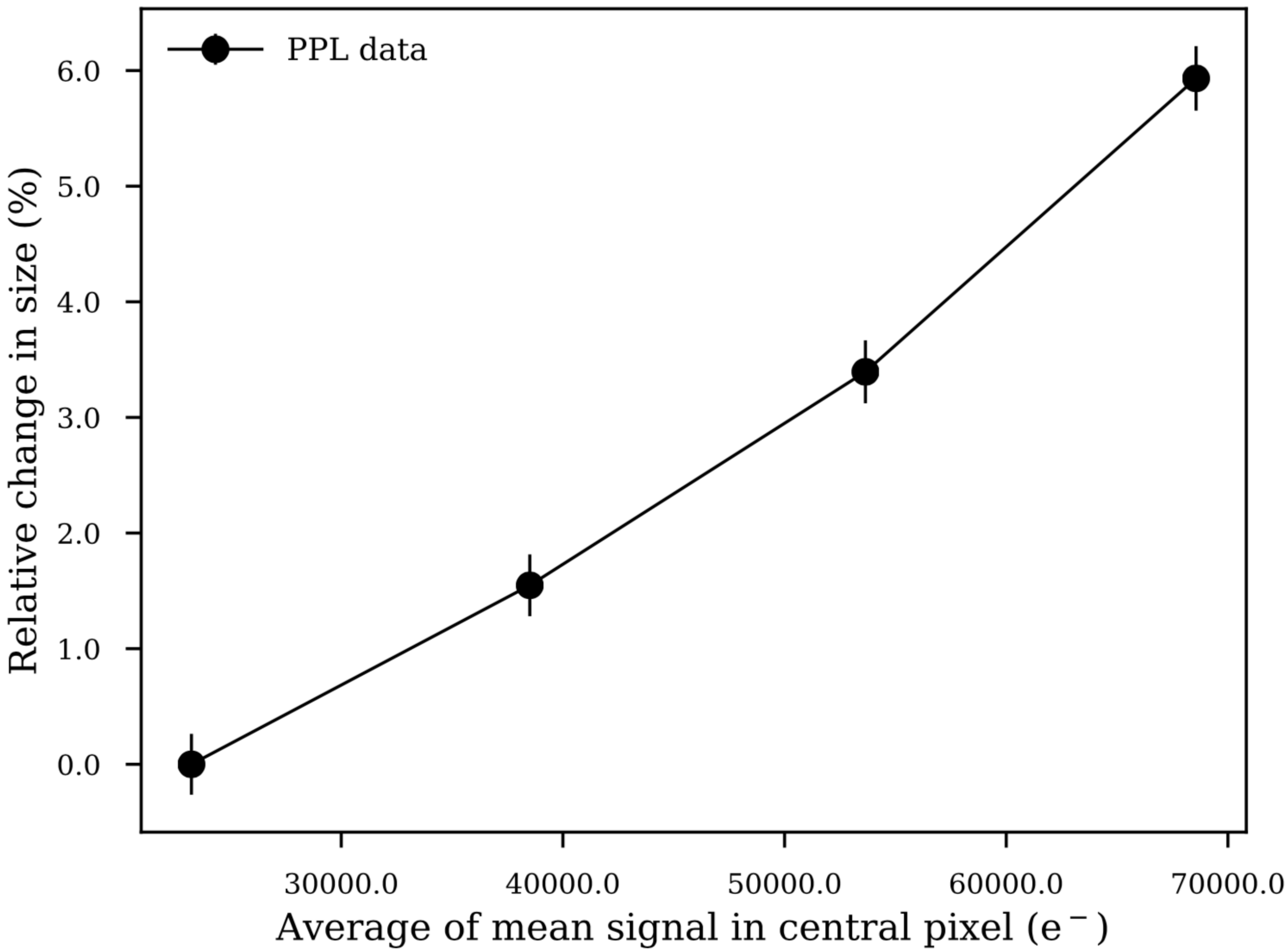


$$S = C_0 + C_1 t + C_2 (C_1 t)^2$$

Non-linearity calibration using flats



Relative change in size



Estimating change in pixel area

$$\frac{dQ}{dt} = F(t) = F_0\left(1 + BQ_c(t)\right) = F_0\left(1 + BF_c t\right),$$

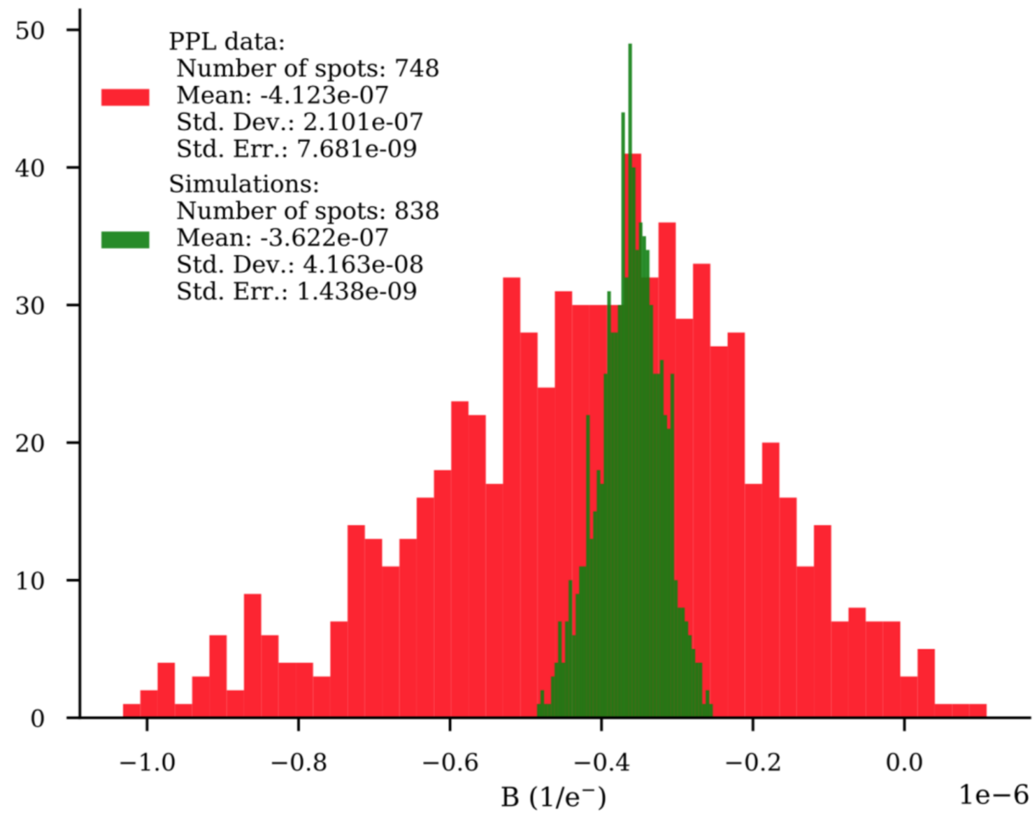
$$Q_c = Q_{central} - (Q_{left} + Q_{right} + Q_{top} + Q_{bottom})/4$$

$$Q_c = F_c t$$

$$f_N = \frac{BF_1F_c\Delta t}{F_*}k$$

$$B = \frac{m}{F_c}\left(\frac{F_*}{F_1\Delta t}\right)$$

B quantifies the area change (dA/A) per e− of contrast Q_c



Thanks!